

Program

Applications of electron microscope for the characterization of catalytic materials

Electron microscopy block course at the Dalian Institute of Chemical Physics

by

Prof. Armin Feldhoff

Leibniz University Hannover, Germany

On Wednesday 14 March 2018, instrument check for SEM and TEM will be made together with lab manager Dr. Miao Shu to be prepared for practical exercises SEM-1 to SEM-8 and TEM-1 to TEM-8. Each number refers to a group of 4 students.

12 to 16 March 2018

	Lectures			Excercises		Examination
	Monday 2018/3/12	Thursday 2018/2/13	Wednesday 2018/3/14	Thursday 2018/3/15		Friday 2018/3/16
8:15 - 9:00	Lecture 1-1	Lecture 2-1	Lecture 3-1	SEM-1	<u>TEM-8</u>	Written test
9:00 - 9:45				SEM-2	TEM-1	break
9:45 - 10:00	break	break	break	break		
10:00 - 10:45	Lecture 1-2	Lecture 2-2	Lecture 3-2	SEM-3	TEM-2	
10:45 - 11:30				SEM-4	TEM-3	
11:30 - 14:00	end of day 1	end of day 2	end of day 3	break		
14:00 - 14:45				SEM-5	TEM-4	
14:45 - 15:30				SEM-6	TEM-5	Final discussion: results of test, certificate
15:30 - 16:15				SEM-7	TEM-6	end of day 5
16:15 - 17:00				<u>SEM-8</u>	TEM-7	
17:00				end of day 4		

Lectures

Lecture 1-1, Basics of the scanning electron microscope I (SEM)

de-Broglie wave length, Lorentz force, electron sources, electron lenses (what does a lens do?), detectors, microscope column, beam-specimen interaction, excitation volume, stigmators, deflectors

Lectures 1-2 + 1-3, Basics of the scanning electron microscope II (SEM)

beam-specimen interaction, detectors, secondary electrons (SE), backscattered electrons (BSE), depth of focus, in-lens detection (high-resolution SEM), avoiding specimen charging, C_s/C_c -corrected SEM (ultra-high resolution)

Lecture 2-1, Basics of the transmission electron microscope I (TEM)

history, virology, fundamentals, lens in wave optics, the 3-stage TEM, optical path for imaging and diffraction, resolution limit, Fourier optics, diffraction absorption contrast

Lecture 2-2, Basics of the transmission electron microscope II (TEM)

phase contrast (high-resolution TEM), phase-amplitude diagrams, $\lambda/4$ phase plate, phase-contrast transfer function, point resolution, delocalisation, C_s -corrected microscope, contrast simulation (multislice method), focal series reconstruction

Lecture 3-1, Diffraction and elemental analysis in the transmission electron microscope

analogies and differences between electron diffraction and x-ray diffraction, selected area electron diffraction (SAED), from parallel to convergent illumination, convergent beam electron diffraction (CBED), scanning transmission electron microscopy (STEM), analytical electron microscopy (AEM), x-ray spectroscopy (EDXS, WDXS, EMPA), electron energy-loss spectroscopy (EELS)

Lecture 3-2, Some practical advice (SEM + TEM)

sample preparation, media for image acquisition, avoiding beam damage

Practical Exercises

SEM (8 courses times 4 students = 32 students; all courses given by lab manager Dr. Miao Shu)

Demonstration of effect of working distance (objective lens focal length) on resolution and depth of focus; secondary electron imaging and energy-dispersive X-ray spectroscopy.

TEM (8 courses times 4 students = 32 students; all courses given by Prof. Armin Feldhoff)

Demonstration of absorption contrast (bright-field, dark field) and selected area electron diffraction; how to avoid damage of beam-sensitive materials during observation.

Examination

Written test (45 minutes) allows monitor the transfer of knowledge. Final discussion on results of test and issuing a certificate will close the block course.